Geochronology of Weathering and Pedogenesis

PAULO M. VASCONCELOS[123]

[1]The University of Queensland, School of Earth Sciences, Brisbane, Qld 4072; paulo@earth.uq.edu.au

The combination of $^{40}Ar/^{39}Ar$, (U-Th)/He, and U-series dating of weathering-product and pedogenic Mn and/or Fe oxyhydroxides permits determining the chronology and rate of chemical reactions in the weathering crust. These methodologies are complementary and suitable for dating processes spanning from Recent to the earliest preserved weathering profiles on Earth. The application of these methods in weathering geochronology reveals that minerals hosted in pedoliths are invariably much younger then minerals preserved in the underlying saproliths, indicating that the pedolith has a much greater propensity to undergo mineral dissolution-reprecipitation than the remainder of the weathering profile. The greater reactivity of the pedolith appears to be controlled by organic activity, mechanical and chemical, which promotes frequent and recurrent mineral dissolution-reprecipitation. In contrast, the underlying saprolith appears to record the influx of weathering solutions during the early stages of evolution of a weathering profile. Once precipitated, saprolith minerals may remain in metastable equilibrium, sometimes for millions or tens-of-millions of years. Saprolith minerals become more prone to dissolve and reprecipitate when the pedolith front advances into the saprolith, But only during drastic changes in weathering conditions do minerals within the saprolith undergo dissolution-reprecipitation. Identifying and dating the multiple generations of supergene minerals in both the pedolith and saprolith reveal a history of weathering that is protracted and episodic, particularly in the case of deep and stratified lateritic weathering profiles. The major challenges in applying these geochronological approaches to the study of weathering and pedogenesis is the difficulty in identifying and physically sampling distinct generations of supergene minerals. This challenge is particularly accute in the pedolith.

Gas discharges for continental Spain: Geochemical and isotopic features

ORLANDO VASELLI[1,2]. BARBARA NISI[3], FRANCO TASSI[1,2], TOM DARRAH[4], JORDI BRUNO[5], JAVIER ELÍO[6], FIDEL GRANDIA[7] AND LUIS PEREZ DEL VILLAR[8]

[1]Department of Earth Sciences, Florence, Italy (*correspondence: orlando.vaselli@unifi.it)
[2]CNR-IGG, Institute of Geoscience & Earth Resources Florence, Italy
[3]CNR-IGG, Institute of Geoscience & Earth Resources Pisa, Italy
[4]Division of Earth & Ocean Sciences, Nicholas School for the Environment, Durham, USA
[5]Amphos21, Barcelona, Spain
[6]Fundación Ciudad de la Energía (CIUDEN), Ponferrada, Spain
[7]CIEMAT, Unidad de Integración de Sistemas Geologicos Madrid, Spain

In this work the results of a geochemical and isotopic survey of 37 gas discharges was carried out in continental Spain are presented and discussed. On the basis of the gas chemical composition, four different areas can be distinguished, as follows: 1) Selva-Emborda (SE) region; 2) Guadalentin Valley (GV); 3) Campo de Calatrava (CC) and 3) the inner part of Spain (IS).

The SE, GV and CC areas are characterized by CO_2-rich gases, while IS has N_2 as main gas compound. The CO_2-rich gases can be distinguished at their turn on the basis on the helium and carbon isotopic composition. The SE and CC areas have a strong mantle signature (up to 3 Ra). Nevertheless, the carbon isotopic composition of CC is within the mantle range and that of SE is slightly more negative (down to -8‰ PDB). The GV gases have a lower mantle signature (≈1 Ra) with respect to SE and CC and more negative carbon isotopes (≈-10‰ PDB). It is worth to mention that the SE, GV and CC areas are related to the youngest volcanic activity in continental Spain, for example the Garrotxa Volcanic Field in Catalonia records the latest event dated at 10,000 years, and the isotopic features, particularly those of helium, are suggesting the presence of magmatic bodies still cooling at depth. The N_2-rich gases, i.e. those from the IS area, has an atmospheric origin, as highlighted by the N_2/Ar ratio that ranges between those of air and ASW (Air Saturated Water). The isotopic composition of carbon is distinctly negative (down to -21‰ PDB) and that of helium is typically crustal (0.02-0.08 Ra), confirming that these gas discharges are related to a relatively shallow source.

www.minersoc.org
DOI:10.1180/minmag.2013.077.5.22

Gas discharges from continental Spain: geochemical and isotopic features

ORLANDO VASELLI[1,2], BARBARA NISI[3], FRANCO TASSI[1,2], TOM DARRAH[4], JORDI BRUNO[5], JAVIER ELÍO[6], FIDEL GRANDIA[7], LUIS PEREZ DEL VILLAR[8]

[1]Department of Earth Sciences, Florence, Italy
[2]CNR-IGG, Institute of Geoscience & Earth Resources Florence, Italy
[3]CNR-IGG, Institute of Geoscience & Earth Resources Pisa, Italy
[4]School of Earth Sciences, **The Ohio State University,** Columbus, USA
[5]Amphos21, Barcelona, Spain
[6]Fundación Ciudad de la Energía (CIUDEN), Ponferrada, Spain
[7]CIEMAT, Unidad de Integración de Sistemas Geologicos Madrid, Spain

Main sponsors

GOBIERNO DE ESPAÑA

ciudad de la energía

CONSIGLIO NAZIONALE DELLE RICERCHE
National Research Council of Italy
ISTITUTO DI GEOSCIENZE E GEORISORSE
Institute of Geosciences and Earth Resources

Aims: recognition of CO_2 analogs and definition of sites where CO_2 might be stored at depth.

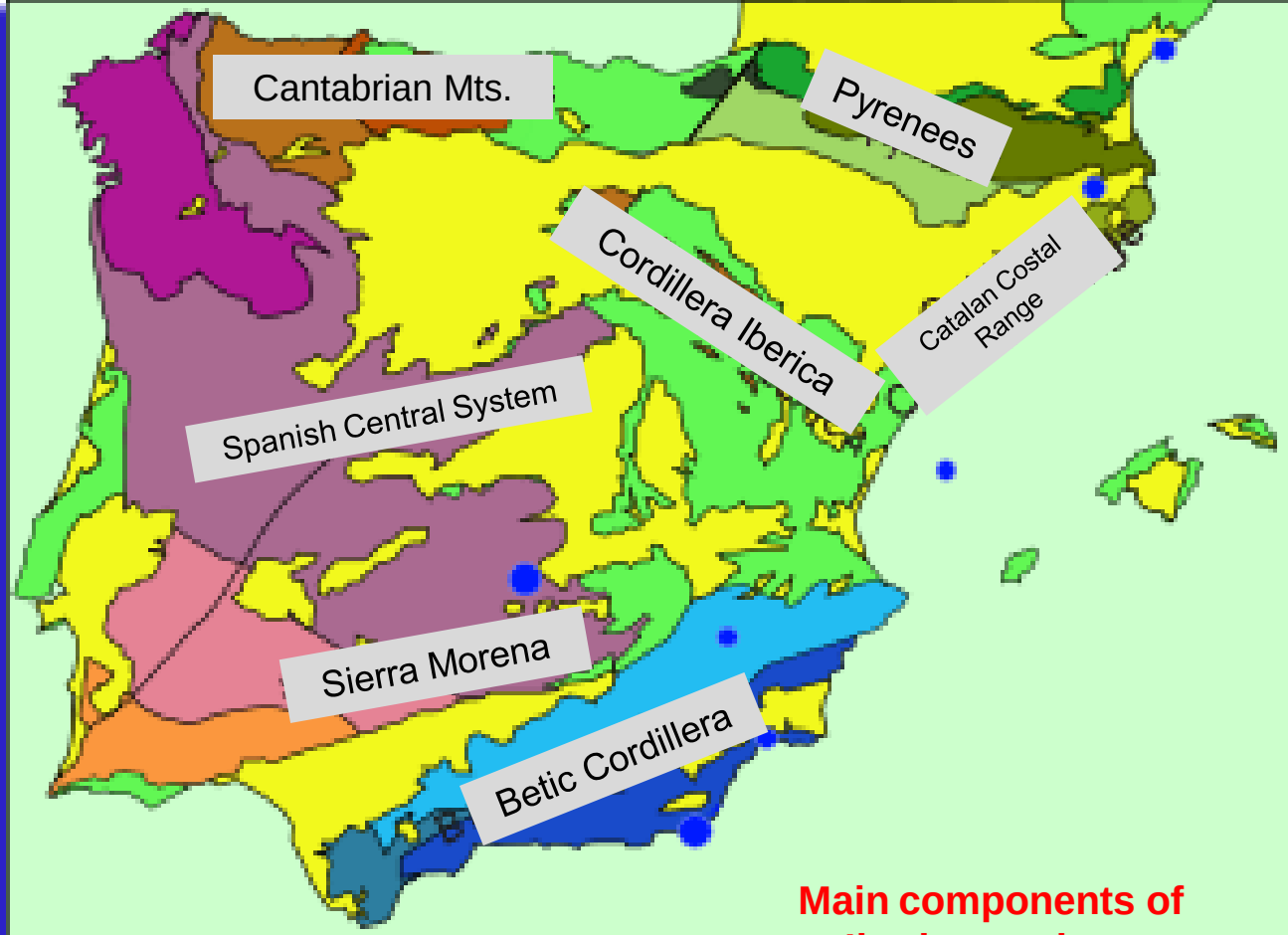
A pilot site was selected close to Burgos (N Spain) and at the end of 2013, 20,000 tons of CO_2 will be injected.

FLORENTINA STUDIORUM UNIVERSITAS

Dipartimento di Scienze della Terra

The main goal of this work is that to provide a general geochemical and isotopic characterization of the main gas discharges in the Continental Spain (for this reason I asked for a poster), since, to the best of our knowledge, only few and local studies have been performed.

The (relatively old) geological history of Spain is not apparently favorable to the presence of significant CO_2-rich degassing areas. However, the most recent 3 volcanic areas (Neogene in age), located along a well-defined alignment, can be regarded as the best promising sites in this respect.



Main components of Iberian geology

Iberic Massif

- Cantabrian Zone
- West-Asturian Leones Zone
- Central Iberian Zone
- Galizia-Trasios-Montesi Zone
- Ossa-Morena Zone
- South Portuguese Zone

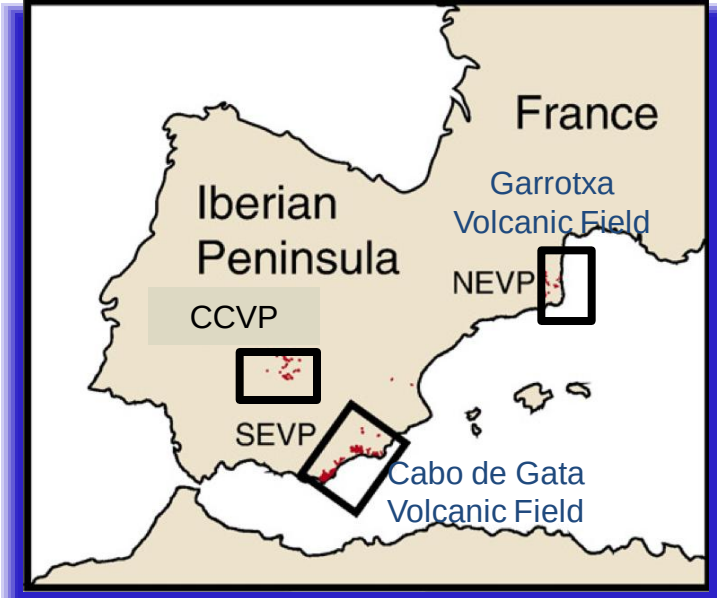
Pyrenees

- North Pyrenees Zone
- Axial Zone
- South Pyrenees Zone

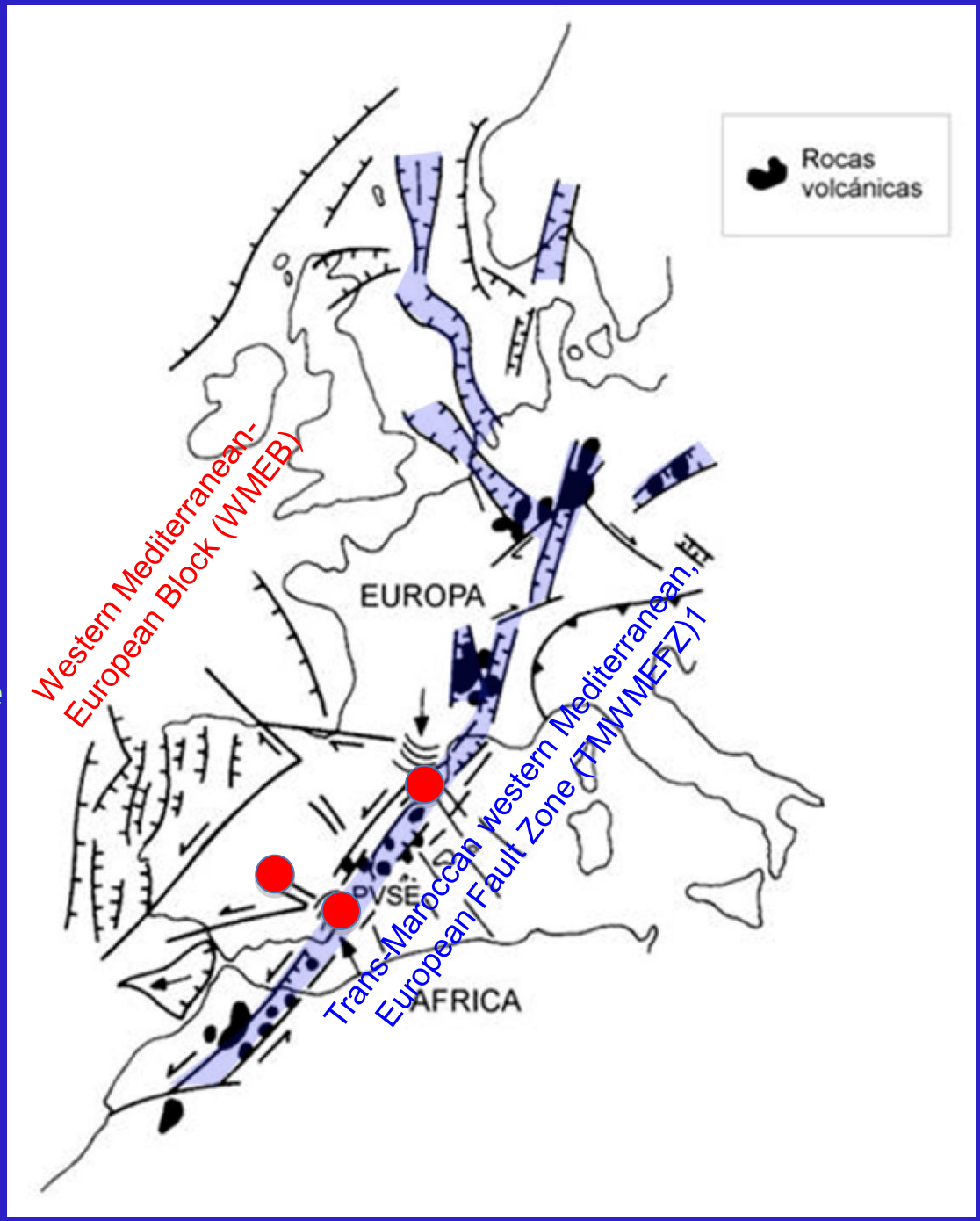
Betic Cordillera

- External Betic Zone
- Gibaltar Complex
- Internal Betic Zone

- Cenozoic Basins
- Mesozoic Basins
- Catalan Coastal Range Palaeozoic Basement
- Neogene volcanics

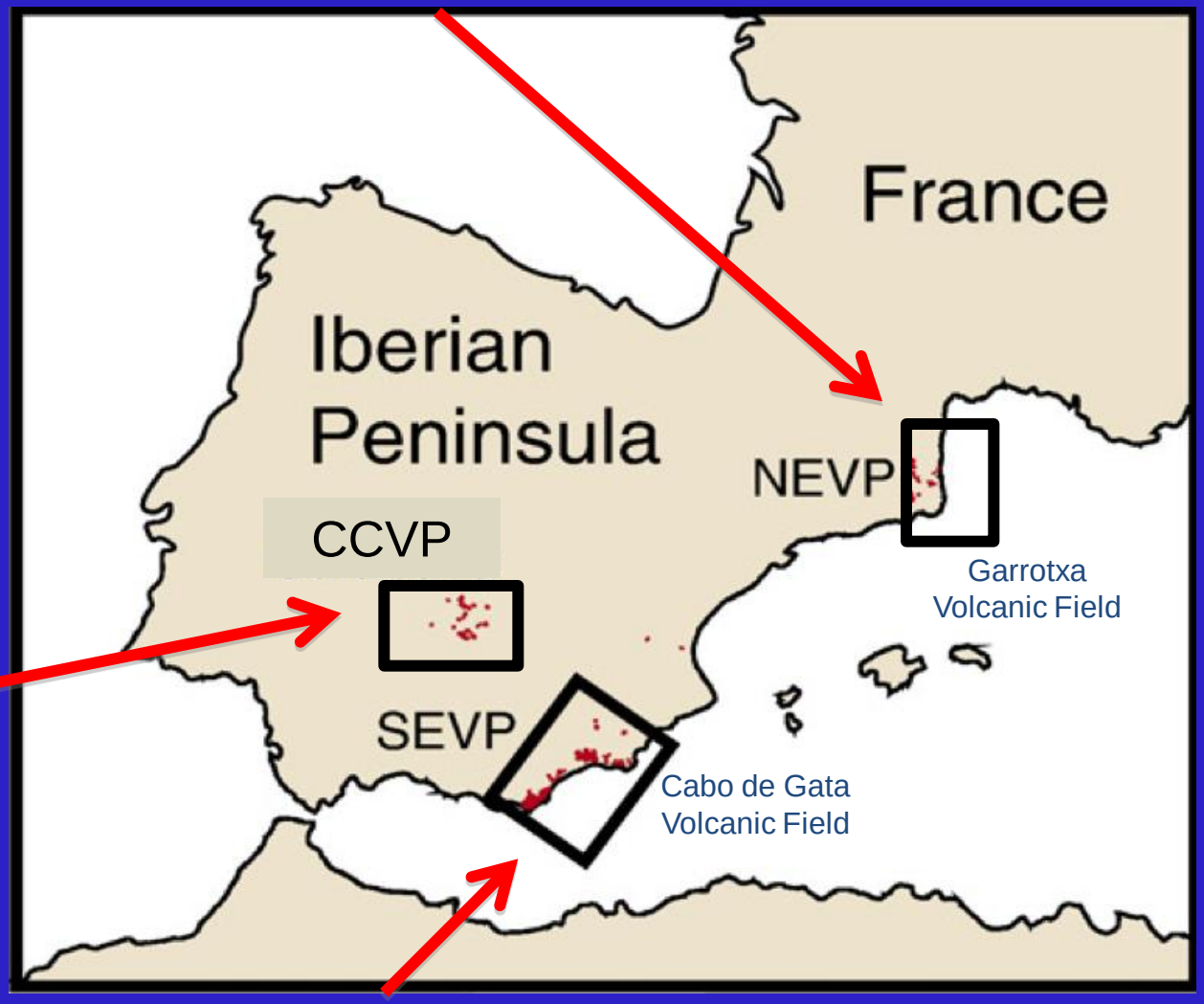


Several hypotheses were proposed to explain the recent volcanism in the Spanish Peninsula. A suggestive one implies that NEVP (or GVF) and SEVP (or CGVF) are part of an aborted rift whose has the highest expression in the Rhine Valley. CCVF would represent a lateral extension of this rift system.

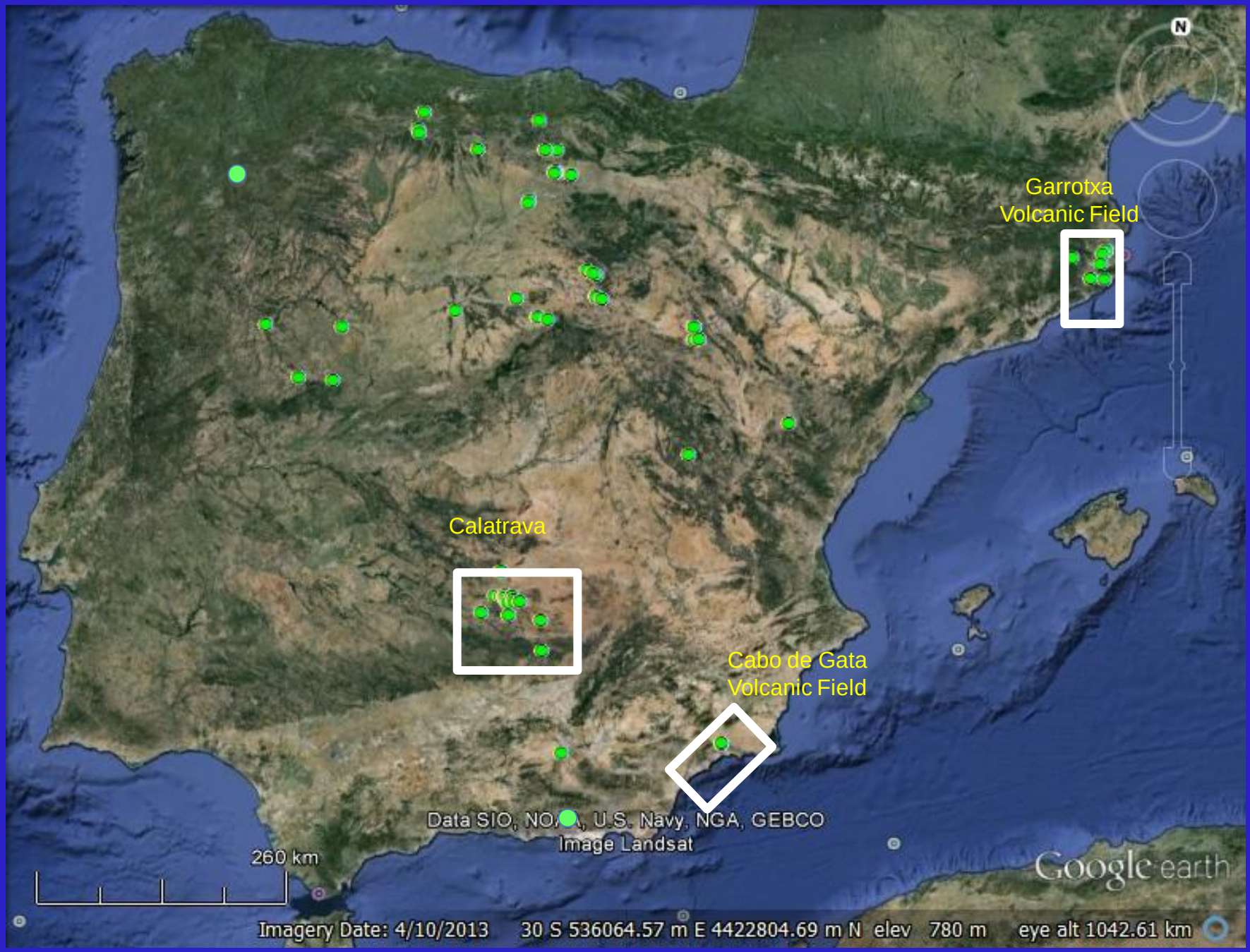


NEVP: about 200 volcanic outcrops irregularly distributed in an area of ca. 2500 km^2. K/Ar ages: Ampurdán (10–9 Ma), Selva (7–2 Ma) and Garrotxa (0.7–0.11 Ma). Plag-thermoluminescence at Garrotxa: 11,500 y.

CCVP: intracontinental plate magmatic association of leucitites, melilitites, nephelinites and olivine basalts extruded during the late Miocene to Quaternary.

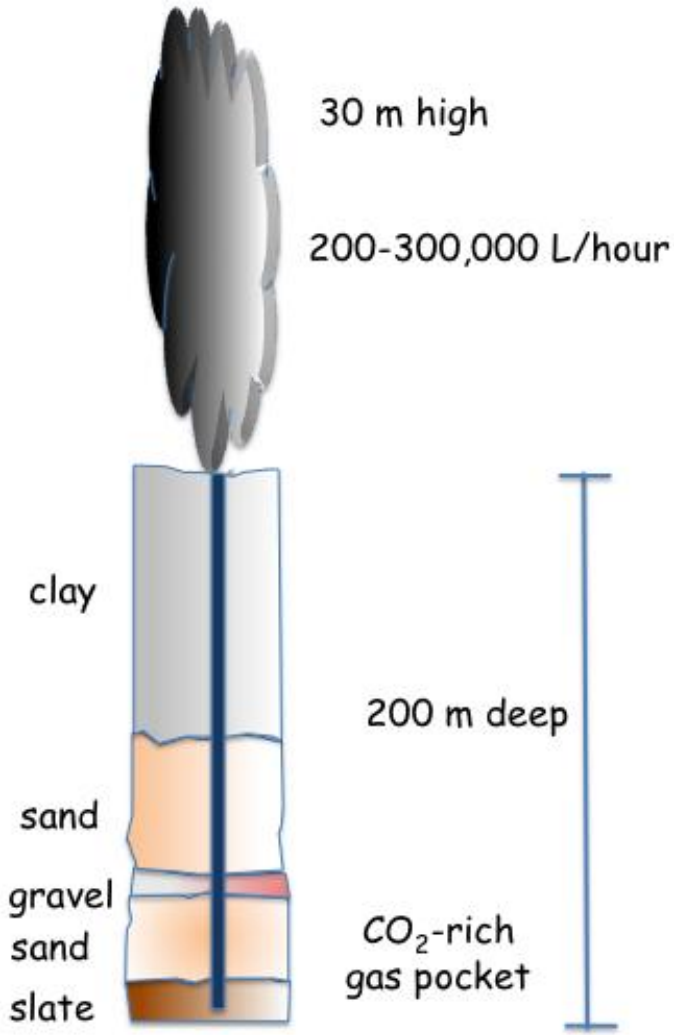


SEVP: Alkali basalts of Pliocene age are the last episode of volcanism in the SEVP, postdating a complex series of Miocene calc-alkaline to U-K rocks.


Garrotxa
Volcanic Field
Calatrava
Cabo de Gata
Volcanic Field
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
260 km
Google earth
Imagery Date: 4/10/2013 30 S 536064.57 m E 4422804.69 m N elev 780 m eye alt 1042.61 km

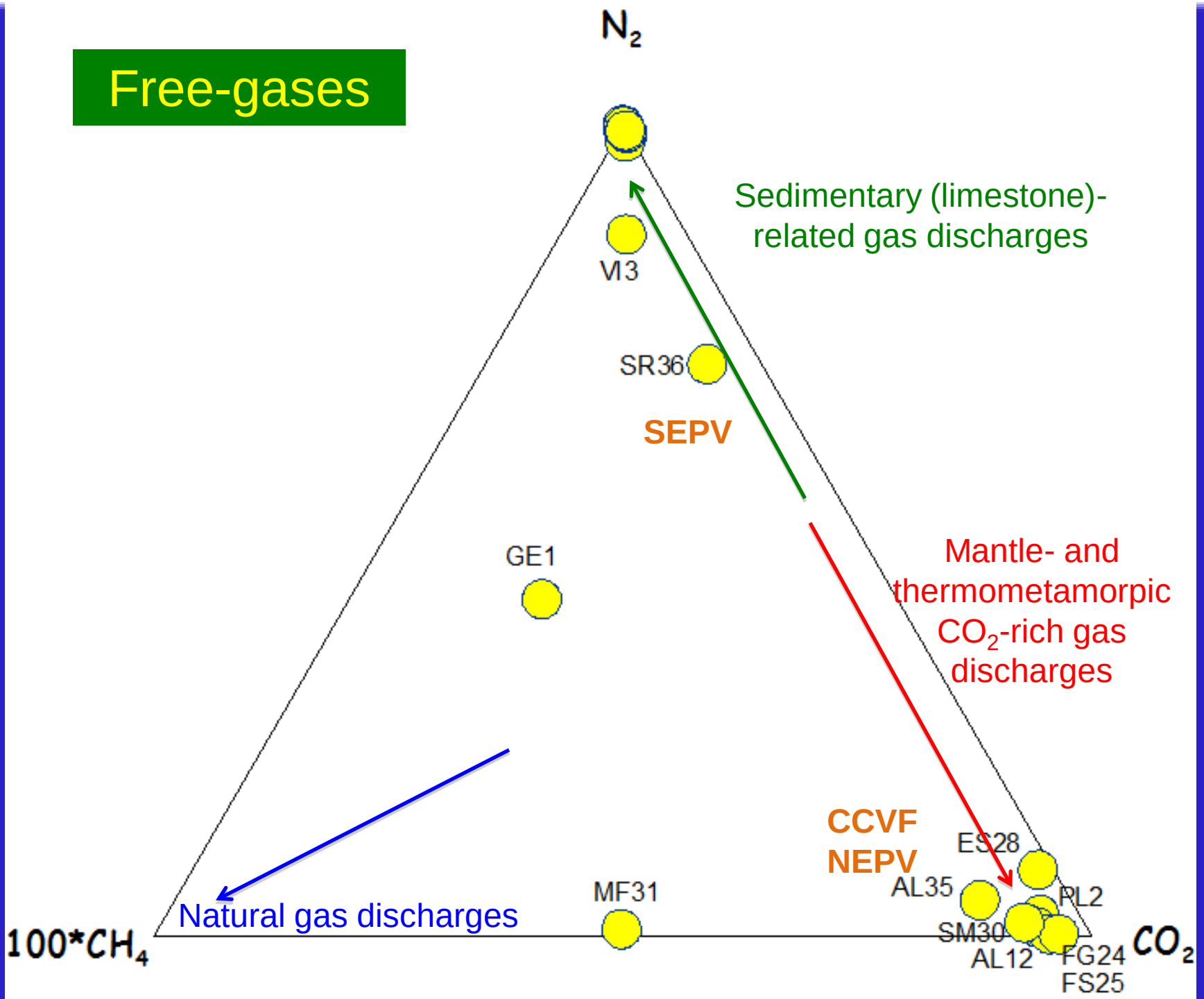

BALNEARIO
BAÑOS DE SERON
FUENTE DE LA PEÑA
AGUA CLORURADO SODICA BICARBONATADA
TEMPERATURA 34°
FUE BENDECIDA POR EL
ILMO. SR. OBISPO DE BUKAREST
EL DIA 16 DE JULIO DE 1862


Estimated CO_2 flux by Open-Path IR Laser Measurements
Open-Path IR Laser Measurements: **8-10 ton/day**

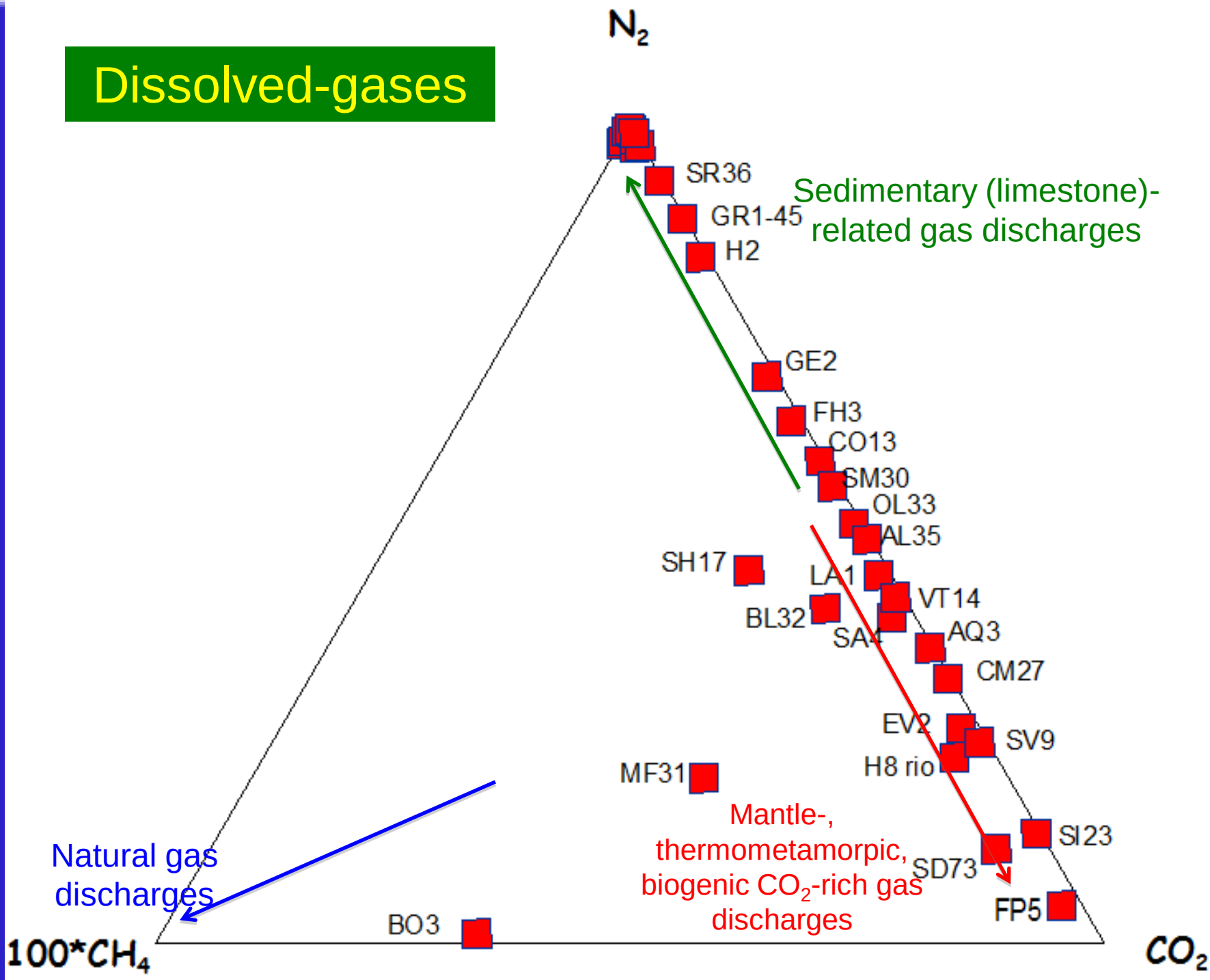


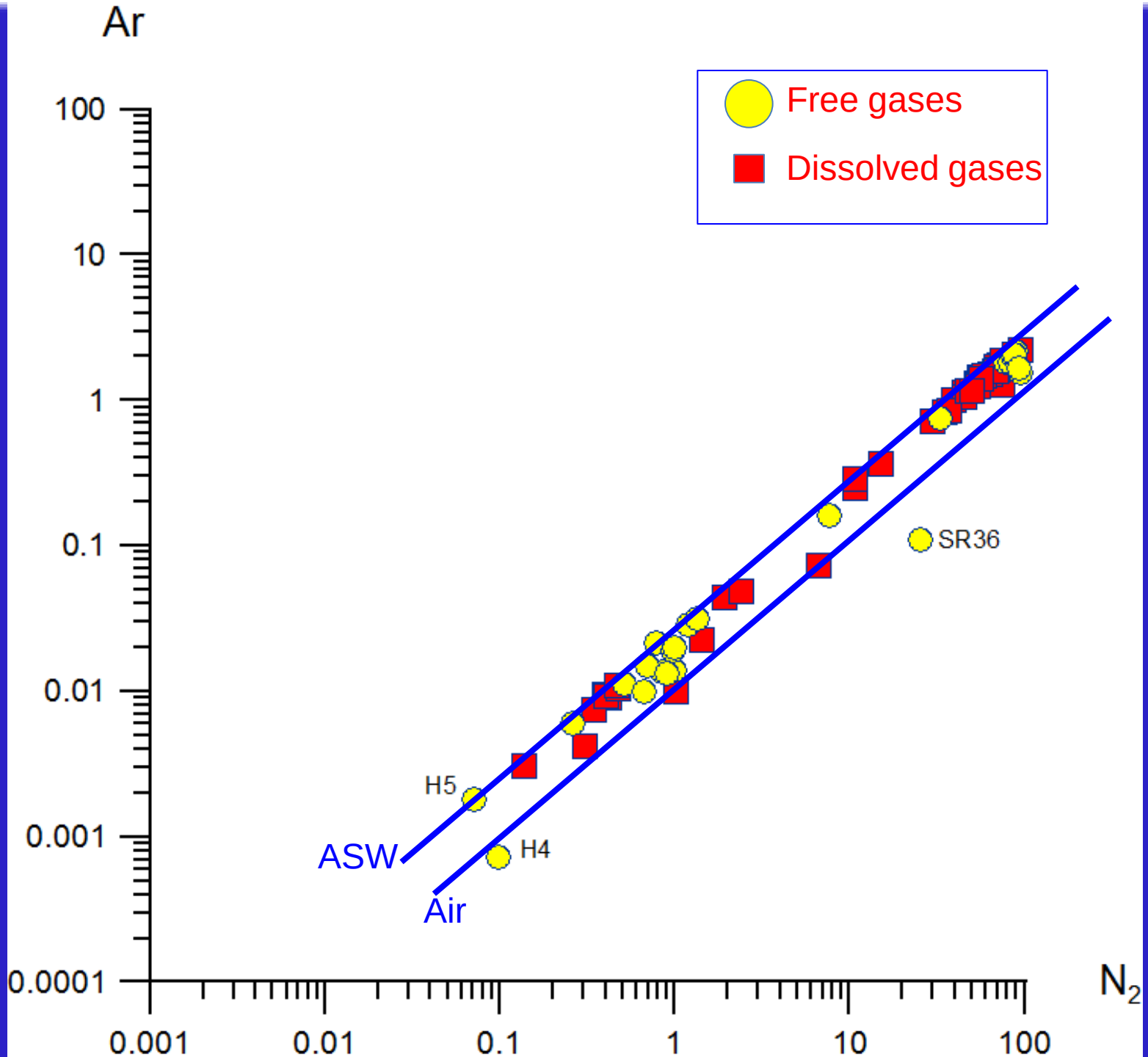
Gas bursts repeatedly occurred when domestic wells were drilled: 2000, 2006, 2011, 2012, 2013.

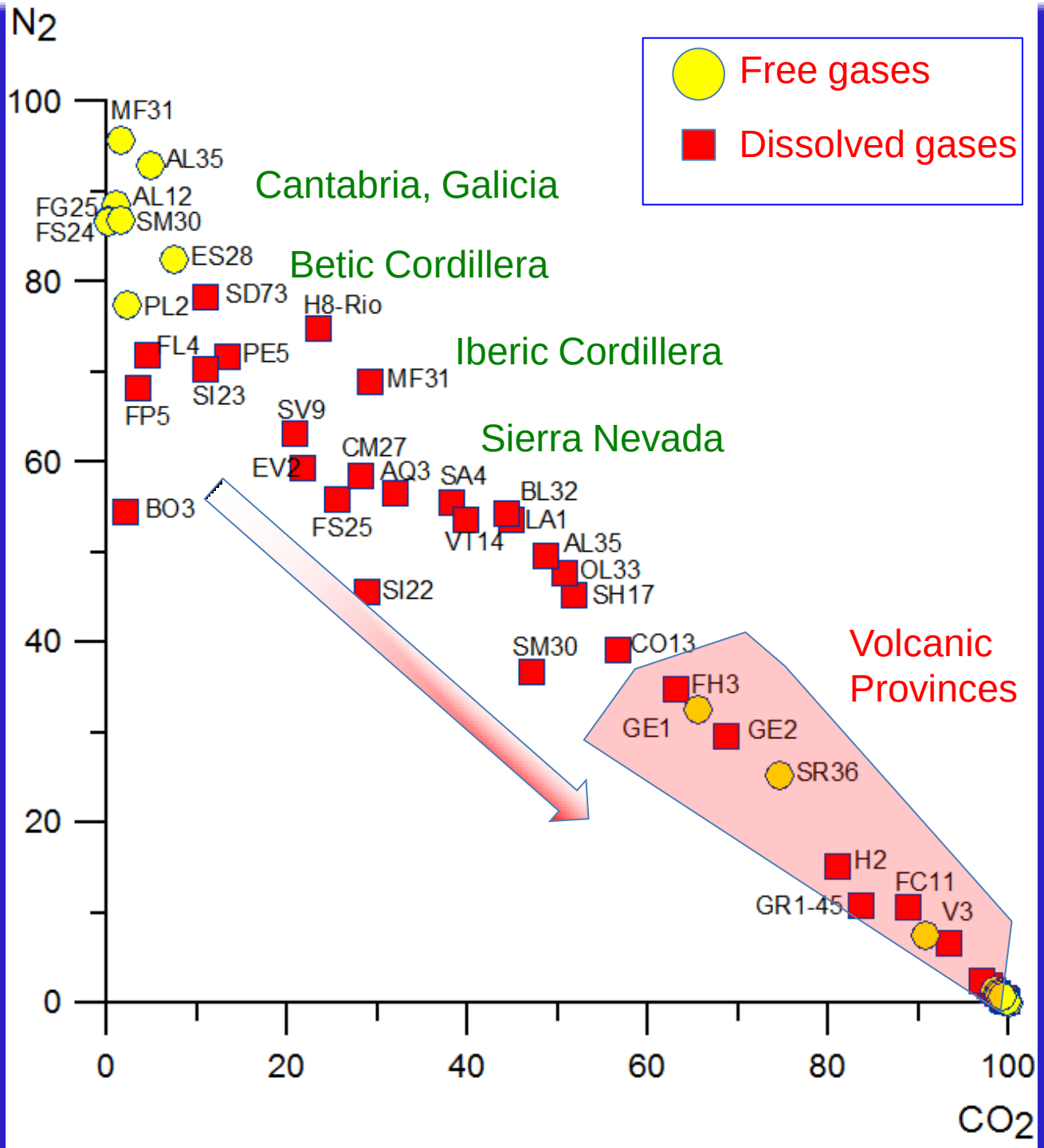
Free-gases

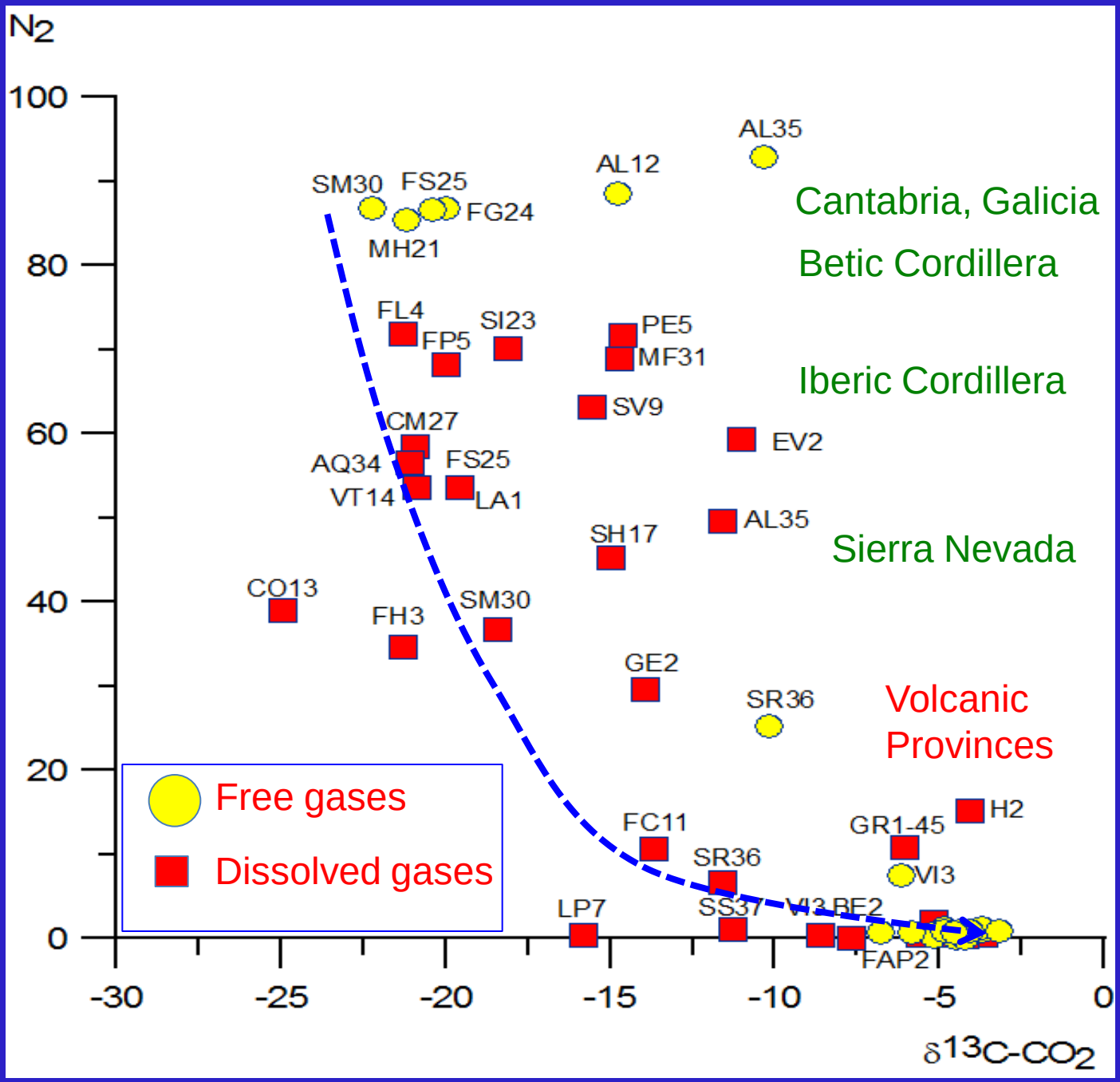

N_2
VI3
SR36
SEPV
Sedimentary (limestone)-related gas discharges
GE1
Mantle- and thermometamorpic CO_2-rich gas discharges
CCVF
NEPV
ES28
AL35
RL2
SM30
AL12
FG24
FS25
MF31
Natural gas discharges
100*CH_4
CO_2

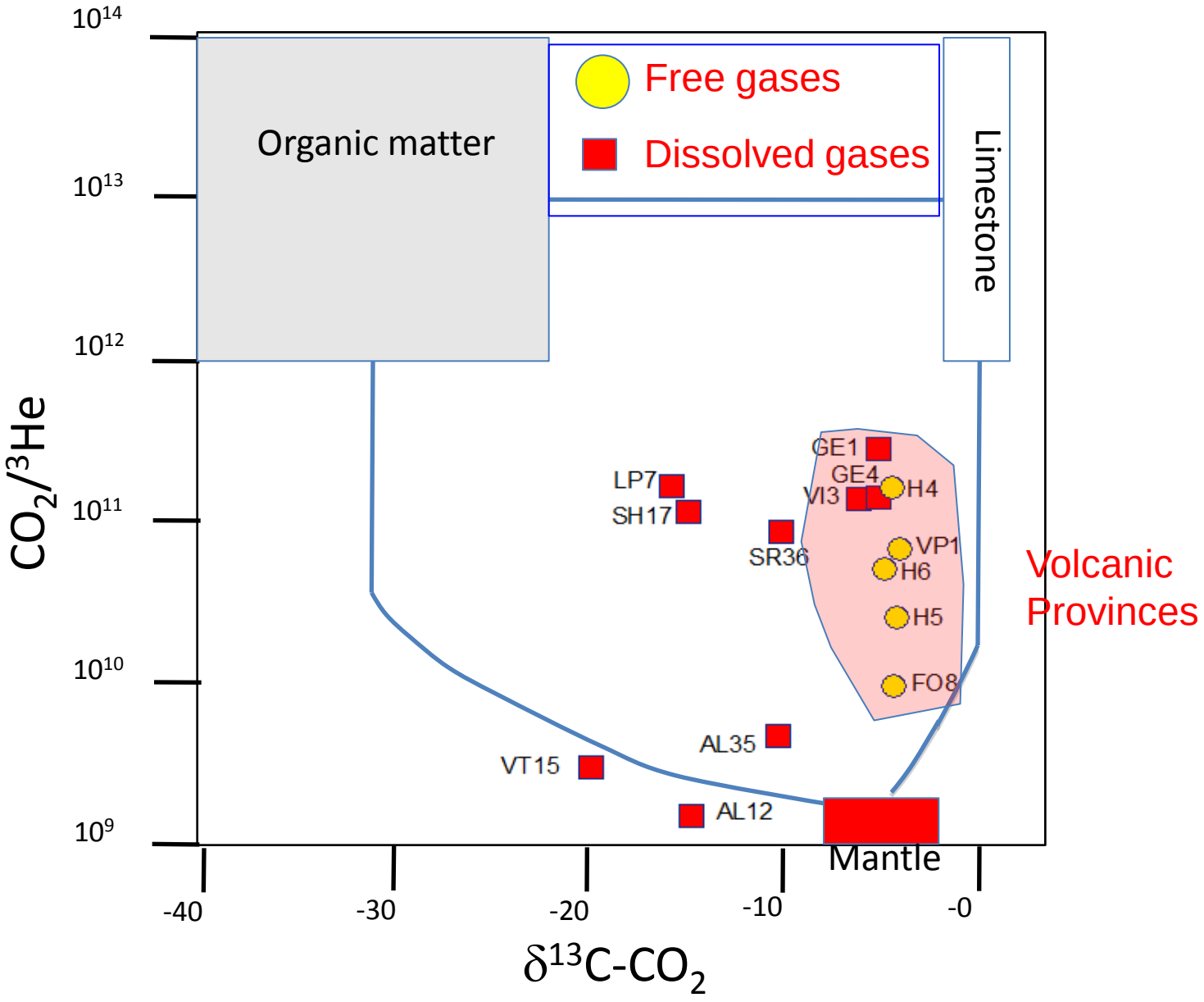
Dissolved-gases




Ar
100
10
1
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
1
10
100
N_2
Free gases
Dissolved gases
SR36
H5
H4
ASW
Air


N2
CO2
Free gases
Dissolved gases
Cantabria, Galicia
Betic Cordillera
Iberic Cordillera
Sierra Nevada
Volcanic Provinces
MF31
AL35
AL12
FG25
FS24
SM30
ES28
PL2
SD73
H8-Rio
FL4
PE5
SI23
FP5
MF31
SV9
EV2
CM27
AQ3
SA4
BL32
LA1
VT14
FS25
BO3
AL35
OL33
SH17
SI22
SM30
CO13
FH3
GE1
GE2
SR36
H2
FC11
GR1-45
V3
0
20
40
60
80
100


N2
100
80
60
40
20
0
-30
-25
-20
-15
-10
-5
0
δ13C-CO2
AL35
AL12
SM30
FS25
FG24
MH21
Cantabria, Galicia
Betic Cordillera
FL4
SI23
PE5
FP5
MF31
Iberic Cordillera
SV9
CM27
EV2
AQ34
FS25
VT14
LA1
AL35
SH17
Sierra Nevada
CO13
SM30
FH3
GE2
SR36
Volcanic
Provinces
Free gases
Dissolved gases
FC11
H2
GR1-45
SR36
VI3
LP7
SS37
V43
BE2
FAP21



R/Ra: NEVP: 2.3; CCVP: 2.1-2.7

Preliminary considerations

- Most of the studied dissolved and gas samples are N_2 or CO_2-dominated, the latter being mainly associated with the three Neogene volcanic provinces;

- CC, SE and NE Volcanic Fields are characterized by relatively high R/Ra values (≳3), which likely suggests the presence of magmatic bodies still cooling at depth. These data are also supported by the $\delta^{13}C$-CO_2 values that are within the magmatic interval, i.e. -6 to -3 ‰ V-PDB);

- Other degassing areas and thermal water discharges are present in Continental Spain are still to be investigated.

Grazie!